



NDIA System Engineering Division
Integrated Diagnostics Committee
Electronics Prognostics Technology

Ground Weapons Task Group

E-Prog II Workshop

24 - 25 January 2006

Ground Weapons (moves,shoots, communicates,detects)

- **There is significant interest on the state of the art in prognostics/diagnostics and a lack of generally available information/standards or data that is readily available.**
- **Great concern over no data exchange between vendors, or proprietary data restrictions from sensing devices or assemblies. Due to large ownership and investment issues, how do we overcome this from a DoD perspective? What are vendors willing to give up in the interest of the community. (I.e failure rates.)**
- **Enormous interest in return on investment studies across the board. Beyond the rtok, cnd, et. Who is doing this? Why aren't we tasking/lobbying this via OSD et.**
- **Seems to be lack of communication even within Services on state of the art, lack of visibility into ongoing Service and industry efforts.**
- **Unified Data Theory for all Dod weapons systems. Capture all info, continuous refinement, allow for Service Specific environmental needs, so that the bounds for prognostic/diagnostic requirements are captured.**
- **Repetitive work being done across the Services by the vendors; how can the DoD better broker this?**

Ground Weapons (moves,shoots, communicates,detects)

- FCS, Stryker, M88, EFV, LAV, FMTV, FTTS,
- Many companies interested in what is happening in prognostics/diagnostics; others pursuing development and capability (fpga prognostics, solder prognostics et.).
- Need to encourage participants to connect with Program offices to derive weapons systems specific details and intent.
- No requirements seem in evidence among the group regarding prognostics requirements emerging from many of the program offices. In some cases, even BIT is tacked on, after the fact.
- How to create the need case amongst DoD for Prognostics and prognostics requirements.(goes back to ROI case; harder for ground vice air/ship)

FCS

Weapon System and Application	FCS will be forwarded later pending approval via ID chairs. Cliff Wenrick.
E-Prog Need Details	(will also be setting up Prognostics Team intra-FCS)
Development Program Elements	(commentary; where are the cost benefits analysis of the various methods; fuses, canaries; how do you use this to influence the designer) How would you do the 'best' technology assessment, with large #s
Current S&T, RDT&E and V&V Applicability	FCS will integrate with current and future force prognostics/
S&T, RDT&E and V&V Needs and Development Program Timelines	

Army IETM interface

Weapon System and Application	Tactical Light, Medium, Heavy Systems(MSD based ietms)(Army)
E-Prog Need Details	Coordinate progn diagn needs with ietm/msd; I.e maintainer connection
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	
S&T, RDT&E and V&V Needs and Development Program Timelines	Ongoing, TACOM next gen ietm software EMS 06 ; not all vehicles will migrate.

Stryker

Weapon System and Application	Stryker Powerpack (caterpillar/allison) limited vendor data support
E-Prog Need Details	Access; how do you provide assurance that proprietary data is protected yet usable. ATEC has the vdl's library capability. (possible future shareable framework (Nat Albritton)
Development Program Elements	BIT added after design; added at 3 rd Brigade level. Institutional limits to diagnosis to LRU level; capable of
Current S&T, RDT&E and V&V Applicability	Continuous testing/dedicated; some prognostics efforts in comm equip.

Span of equipment (comment)

Weapon System and Application	General communication gear shows a dearth of prognostics; also handheld GPS; We need to consider all types of systems.
E-Prog Need Details	
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	
S&T, RDT&E and V&V Needs and Development Program Timelines	

Comment

Weapon System and Application	Stryker, FCS, EFV; what are the combined prognostics needs; where does this all lead into the future?
E-Prog Need Details	Dearth of electronics physics models/mechanisms of failures in non-simplistic environments.
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	
S&T, RDT&E and V&V Needs and Development Program Timelines	

FMTV

Weapon System and Application	FMTV (Stewart-Stevenson)
E-Prog Need Details	Interested in prognostics diagn.
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	Next gen vehicle 07; cost a factor; but what is out there; what is possible?
S&T, RDT&E and V&V Needs and Development Program Timelines	

FTTS

Weapon System and Application	Prognostics and diagnostic on generator sets (future tactical transport system)
E-Prog Need Details	Interested in prognostics diagn.and how is this data made meaningful
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	Need basic research and algorithms.
S&T, RDT&E and V&V Needs and Development Program Timelines	

More FCS

Weapon System and Application	Aberdeen doing extensive sw v&v planning
E-Prog Need Details	
Development Program Elements	<p>V&V plan in 06. for prog and diag software on the FCS. Actual testing FY07</p> <p>Companies not seeing requirements for prognostics; due to extra costs, prog probably not offered;</p> <p>Significant testing redundancy occurring across multiple companies; how can you normalize via DoD? Dod would have to be the factor/broker; currently not happening.</p>
Current S&T, RDT&E and V&V Applicability	

ARL

Weapon System and Application	Temp humidity, vibration, shock miniturized sensors for munitions. ROI could be up to 65% in future munitions.
E-Prog Need Details	May be open source to other DoD entities.
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	More assets; need more insertion opps from field users. Sustainability maintainability, survivability;
S&T, RDT&E and V&V Needs and Development Program Timelines	

Tracked Vehicles

Weapon System and Application	M88-A2,Bradleys, Paladins, M113,FCS
E-Prog Need Details	Interested in prognostics diagn. And to see what is possible
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	Research in progress.
S&T, RDT&E and V&V Needs and Development Program Timelines	

EFV

Weapon System and Application	Expeditionary Fighting vehicle
E-Prog Need Details	CBM postponed by ONR due to funding constraints Warnings, Cautions and Advisories <ul style="list-style-type: none"> • Built-in-Test • Third Echelon Test System • ONR Condition Based Need driven maintenance; minimum maintenance.
Development Program Elements	
Current S&T, RDT&E and V&V Applicability	Research in progress.
S&T, RDT&E and V&V Needs and Development Program Timelines	Will be resuming CBM efforts in the 2007-2008 timeframe.

comment

Weapon System and Application	DRS sees lack of data sharing between ATE and vehicle; physics of failure; common modeling techniques at the vehicle level lacking
E-Prog Need Details	Cost benefit tradeoff across when it would be cost effective to pursue different approaches for prognostic
Development Program Elements	1 Sensor vice physics of failure 2 Data mining of sensor data 3 Statistical mining of data
Current S&T, RDT&E and V&V Applicability	
S&T, RDT&E and V&V Needs and Development Program Timelines	

Some companies pursuing dc to dc power converter prognostics; solder joint failure sensors; fpga prognostic capability, can detect in-situ monitoring of solder joints, fault to failure estimate modeling, physics of failure, empirical based; combining real world with models; refine the guess with accrued data;

Completed Sample E-prog Template

Weapon System and Application	CVN-21 - EMALS
E-Prog Need Details	<ul style="list-style-type: none">•Power electronics prognostics –24 hours / 70% confidence
Development Program Elements	<ul style="list-style-type: none">•S&T – sensing/detection techniques – failure models –Prognostics algorithms•RDT&E – demonstration on military system•V&V – Field Testing and Evaluation
Current S&T, RDT&E and V&V Applicability	<ul style="list-style-type: none">•Electronic carrier migration models
S&T, RDT&E and V&V Needs and Development Program Timelines	<ul style="list-style-type: none">•IOC 2011•Development Program Through V&V 4 years

Prognostics Definition and Terms of Reference

- **PROGNOSTICS** - **A “FORECAST OF FUTURE PERFORMANCE AND / OR CONDITION”.**
- **Prognostic Accuracy or Confidence Level** – the accuracy in terms of difference between the future forecast of performance or condition and the actual future value achieved expressed as +/- an amount or as a percentage of the forecast. It may also be applied to the accuracy of the predicted time to failure, time to a given performance degradation point or percentage, remaining useful life, etc.
- **Prognostic Horizon** – the maximum time or related parameter (such as number of missions, etc.) for which a given Prognostic Technique will achieve a set accuracy or confidence level. For example, technique “A” may achieve a 90% prognostic accuracy with a horizon of 200 operating hours, or Prognostic Technique “B” may achieve a 75% prognostic accuracy with a prognostic horizon of 3 missions.
- **Prognostic Metrics** – those measures of performance of a prognostic technique or system that characterize the performance and predictive reliability of that technique or system for a specific application. These metrics may include:
 - Demonstrated versus design prognostic accuracy / confidence level.
 - Demonstrated versus design prognostic horizon.
 - Demonstrated reliability of the prognostic system versus the system it monitors.
 - Applicability or robustness of the prognostic technique or system – how many other applications can the technique be applied to with commensurate accuracy, reliability and horizon attributes.

NAVAIR Tasking

“Identify the types of diagnostic data that should be collected for use in providing an electronic systems prognostic capability”

Requested by:

John Kelly

USNCIV NAVAIR 2133

Key Points From the Three Workshop Sessions

- Electronic Prognostics Requirements –The need for prognostics on electronic systems is common to many current and new weapon system programs. As electronic systems start to represent higher percentages of weapon system content, the urgency of addressing this issue increases.
- Current Electronic Prognostic Applications & Tools – There is a baseline set of tools and practices that are currently available and/or in use for prognostics of certain specific types of electronic systems. Some models as well as tools for modeling and data mining for electronic systems exist and are being applied. Additionally, since many of the electronic failure modes may actually be due to or caused by mechanical failure mechanisms (solder joint failures, PC Board trace breakage, contact corrosion, etc.) it may be prudent to adapt already proven mechanical system prognostic technology to some electronic system prognostic applications.
- Current Electronic Prognostic Research and Development Activities – There are emerging tools and technologies that, when developed, may augment the baseline technology, including the application of nonlinear analytical techniques to detect early onset of faults. One current focus is Power Supply prognostics in currently active JSF sponsored SBIRs, including the use of actual loadings and failure physics to predict solder joint crack initiation and device failure and the potential for tracking BIT “false indications” as potential early indicators of the onset of faults.

Key Workshop Conclusions

- The need for electronic system prognostic capability is prominent in many new weapon systems.
- Electronic System prognostics cannot be fielded now. There appear to be some critical technology shortfalls, especially in the physics of failure modeling and pre-fault sensing areas. Additional R&D and V&V efforts are needed.
- To implement electronic system prognostics in the future, data will have to be tagged to reflect operating environment as well as time.
- While the data required to implement individual electronic system prognostic approaches may vary some, the need for validated operating environment, operating time, historical test and maintenance data may be common to all approaches. Acquisition requirements to capture these data and integration of the process into the maintenance program are viewed as paramount in successful fielding of an electronic system prognostic capability.

Some Recommended Types of Diagnostic Data To Be Collected

- Historical data down to component level
- Cascading fault information
- Data that is relative to the level of repair (For all levels of maintenance)
- Data necessary to distinguish between-function inter-dependency
- Data required by OEM / Organic testing to effectively repair weapons system (eliminate CND, RTOK, BCSs, etc.)
- Performance Data such that the OEM can refurbish weapons system
- All data to facilitate False Alarm root cause analysis (sub-system failure data)
- Time Stamp
- Signal Performance
- Power usage
- Observable precursors to electronic failures (Extension from the Testing World)
- Physics of failure data / models (Standardization of models)
- Parametric Data
- Manufacturing statistical data
- Environmental Data (i.e., Humidity, Temperature)
- Weapon System Operational information (i.e., Pitch, Roll, Yaw, Gs, Acceleration, etc.)
- Weapon System Configuration Data (Hardware and Software)
- Built In Test Data
- Data presented in a standardized format / definition

Recommended Follow on Actions

- Define and prioritize the R&D and V&V tasks required to establish a fieldable electronic system prognostic capability. Categorize these tasks by type of electronics and expected performance and cost benefits.
- Generate a program roadmap for planning, sequencing and funding these tasks. Establish funding sources, transition paths and sponsors and implement the Electronic System Prognostic Capability Implementation (ESPCI) Initiative.

ID Committee Actions

- **Review and Approval of the Final Report - Completed**
- **Forward to the NDIA SE Division as the ID Committee Response to the NAVAIR Tasking - Completed**
- **NDIA SE Division Approval to Act on Recommendations - Completed**
- **Establish Task Group to Act on the Recommendations - In Process - Chaired by Jim Dill (ID Committee)**